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(54) Article comprising a low reflection optical fiber termination

Schwach reflektierendes Endstück für optische Faser

Dispositif de terminaison d'une fibre optique avec rélexion peu élevée

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Description

Field of the Invention

[0001] This invention relates to the field of optical fiber communications. More particularly it pertains to an apparatus that comprises a low reflection optical fiber termination.

Background of the Invention

[0002] Optical fibers have come into wide-spread use as transmission media for communication signals. Applications include video distribution systems, data and voice communications, and sensor signal networks. Both multimode and single mode optical fiber systems are employed for such purposes.

[0003] One of the limitations encountered by optical fiber systems relates to optical noise. A common source of optical noise is optical power reflections. Optical power reflection generally occurs at any discontinuity in a fiber optic transmission path, including the end of an optical fiber, and causes a portion of the incident light to travel back toward the source. Optical power reflected in this manner may reflect again when it arrives at the source point or other points of discontinuity in the system, adding an unwanted noise component to the signal. Optical power that is reflected back into a source can also corrupt the fundamental operation of the source, typically a laser. See for instance, R. Rao et al., Electronics Letters, Vol. 22 (14) pages 731-732 (1986). Control of reflections thus is an important consideration in the design of optical fiber systems.

[0004] It is known that reflections can be essentially eliminated if the fiber end is polished at an angle such that light is reflected at an angle beyond the internal critical angle of the fiber, thereby ensuring that the reflected light is not guided by the fiber. However, polishing typically is a time consuming operation that can considerably increase the cost of an optical fiber system. Another known technique for eliminating back reflection is to cleave the fiber such that a tilted end face results, as is described in Blonder, "Method of Producing Apparatus Comprising a Low Reflection Optical Fiber Connection, " U.S. Patent No. 5,048,908. However, special equipment is needed to perform this operation. Other disadvantages associated with current methods of terminating optical fiber include the possibility of sub-surface damage, fiber breakage and contamination.

[0005] Consequently, an apparatus having a low-reflection optical fiber termination which can be practiced easily, quickly and inexpensively, and that requires no additional or special equipment would be highly desirable. This application discloses such an apparatus.

[0006] Various types of optical fiber connectors are known, including connectors which use index matching liquid to improve optical coupling between the fibers. An example of such a connector is described in, Runge, "Optical Fiber Connector", U.S. Patent No. 4,512,630.

[0007] U.S.-A-5 058 983 discloses an optical article comprising an optical fiber with a core and cladding and a terminator at the end of the fiber.

[0008] U.S.-A-4 998 795 discloses an article similarly comprising a fiber and a terminator.

[0009] According to the present invention there is provided an article as defined in claim 1.

Brief Description of the Drawings

[0010] FIG. 1 is a bidirectional optical coupler having an unterminated end.

[0011] FIG. 2 is a low reflection termination of an optical fiber.

The Invention

[0012] In a preferred embodiment, the invention is an apparatus (i.e. an optical communication system, an optical coupler, etc.) that comprises a low reflection optical fiber termination, schematically illustrated in FIG. 2. Numeral 3 refers to a length of optical fiber, 10 to the terminated fiber end of the optical fiber 3, 18 and 20 refer to the fiber cladding and core, respectively, 22 to the terminator attached to end 10 of the optical fiber 3, 24 to the fiber/terminator interface, and 26 to an appropriate coating which covers the terminator and a portion of the optical fiber. The core has an effective refractive index N (exemplarily, N=1.484±.026 at .589 μm) and the cladding has an effective refractive index n, less than N. The meaning of "effective" refractive index is well known to those skilled in the optical fiber art. The terminator has a refractive index that is close (typically within ±3.5%, preferably within ±2%) to N, the effective refractive index of the fiber core, the index typically being the same throughout the terminator. The coating is typically a UV curable polymer that has a higher effective refractive index than the terminator.

[0013] The apparatus is described in relation to a four port directional optical coupler 2, as schematically illustrated in FIG. 1. Such couplers are well known and do not require detailed description. Suffice it to say that the directional coupler 2 comprises two optical fibers 1 and 3, each having two ends 4 and 8, and 6 and 10 respectively. Exemplarily, end 4 of fiber 1 is connected to an optical transmitter 12 such as a laser; end 8 is connected to an optical fiber transmission link 14; end 6 of optical fiber 3 is connected to an optical receiver 16 and end 10 is the designated end to be terminated. The course of the light from optical transmitter 12 is indicated by the solid-line arrows, and the course of the light coming from the optical waveguide 14 is indicated by the dash-line arrows. If no reflection suppression arrangements were made at end 10, a portion of the light from the transmitter would be reflected at this end 10, as indicated by the dotted-line arrows. The portion of this reflected light that reaches the receiver would constitute noise, degrading system performance.

[0014] According to the invention, attached to end 10 is a terminator, as illustrated in FIG. 2. The terminator exemplarily is a length of core-less, non-guiding (undoped or doped) silica fiber having substantially the same diameter (e.g., 125 µm) as the fiber to be terminated. Such fiber can be readily produced, e.g. by drawing from a silica rod that was formed by collapsing a standard silica tube. When light which is transmitted down the optical fiber reaches the fiber/terminator joint, little to no reflection occurs and essentially all of the light is coupled into the terminator. The terminator is selected such that the coupled-in light is scattered and/or absorbed, and preferably such that minimal to no back reflection occurs at the downstream terminal or air interface. The closer the refractive index of the terminator is to N, the less reflection occurs at the fiber/terminator interface. Use in the terminator of relatively impure material may frequently be advantageous to increase the scattering and/or absorption of the light. The terminator can be attached to the fiber by any appropriate technique, including fusion splicing or using index matched epoxy. The designated end of the fiber to be terminated typically does not require any special treatment, such as polishing, bending, twisting, cleaving or tapering, prior to attaching the terminator. However, conventional fusion splicers typically require that the fiber ends be relatively flat.

[0015] Exemplarily, fusion splicing a standard single mode fiber, (AT&T 5D fiber), having an effective core refractive index of 1.463 to a length of substantially pure SiO_2 fiber (refractive index 1.458) resulted in essentially reflection-free terminations when the length of the terminator was approximately 4 cm or above. When the terminator had a length of 3 cm the back reflection measured was approximately -70 dB. Those skilled in the art will appreciate that the minimum terminator length frequently will depend on terminator composition, with less pure terminator material typically making possible use of shorter terminator. The presence of an appropriate polymer coating can result in further reduced reflection. For example, by coating the above referred to 3 cm long terminator with a UV curable polymer coating 26, negligible back reflection occurred, as compared to -70dB back reflection without the coating.

[0016] Although the invention is described with regard to a directional coupler, those skilled in the art will appreciate that the invention can be used in any apparatus that requires a low-reflection termination of an optical fiber. Other contemplated uses are in optical fiber measurement apparatus and sensing apparatus.

Claims

1. An optical article comprising:

   - an optical fiber (3) having a core (20), and a cladding (18), the core having an effective refractive index N; and

     an elongated body (22) of material having a substantially constant refractive index in the range 0.965N-1.035N throughout the body, the body being attached to an end of said optical fiber so as to constitute a light scattering and/or absorbing terminator characterized in that the cladding of the end portion (10) of said optical fiber and the external surface of the body constituting the terminator are coated with a polymer coating (26).

2. An article according to claim 1, wherein the polymer coating has a refractive index greater than that of the terminator.

3. An article according to claim 1, wherein the terminator has substantially the same diameter as said optical fiber.

4. An article according to claim 1, wherein the terminator is attached to said end of the optical fiber by means of index matched epoxy.

5. An article according to claim 4, wherein said index matched epoxy has a refractive index which is in the range 0.965N-1.035N.

6. An article according to claim 1, wherein the terminator has a length of 3 cm or greater.

7. An article according to claim 1, wherein the terminator is a core-less silica fiber.

8. An article according to claim 7, wherein said core-less silica fiber comprises Ge.

Patentansprüche

1. Optischer Gegenstand, der folgendes umfaßt:

   eine optische Faser (3) mit einem Kern (20) und einem Mantel (18), wobei der Kern einen wirksamen Brechungsindex N aufweist; und

   einen länglichen Körper (22) aus Material mit einem im wesentlichen konstanten Brechungsindex im Bereich von 0,965 N - 1,035 N durch den ganzen Körper hindurch, wobei der Körper an einem Ende der optischen Faser angebracht ist, um einen lichtstreuenden und/oder lichtabsorbierenden Terminator zu bilden, dadurch gekennzeichnet, daß der Mantel des Endteils (10) der optischen Faser und die äußere Oberfläche des den Terminator bildenden Körpers mit einer Polymerbeschichtung (26) beschichtet sind.

2. Gegenstand nach Anspruch 1, bei dem die Polymerbeschichtung einen Brechungsindex aufweist, der höher ist als der des Terminators.

3. Gegenstand nach Anspruch 1, bei dem der Terminator im wesentlichen den gleichen Durchmesser wie die optische Faser aufweist.

4. Gegenstand nach Anspruch 1, bei dem der Terminator mit Hilfe von Epoxidharz mit gleichem Index an dem Ende der optischen Faser angebracht ist.

5. Gegenstand nach Anspruch 4, bei dem das Epoxidharz mit gleichem Index einen Brechungsindex aufweist, der im Bereich 0,965 N - 1,035 N liegt.

6. Gegenstand nach Anspruch 1, bei dem der Terminator eine Länge von 3 cm oder darüber aufweist.

7. Gegenstand nach Anspruch 1, bei dem der Terminator eine kernlose Siliziumdioxidfaser ist.

8. Gegenstand nach Anspruch 7, bei dem die kernlose Siliziumdioxidfaser Ge umfaßt.

Revendications

1. Article optique comprenant:

   une fibre optique (3) possédant un coeur (20) et une gaine (18), le coeur présentant un indice de réfraction efficace N; et
   un corps allongé (22) en matériau à indice de réfraction essentiellement constant dans l'intervalle de 0,965 N à 1,035 N, dans tout le corps, le corps étant attaché à une extrémité de ladite fibre optique pour constituer un dispositif de terminaison diffusant et/ou absorbant la lumière, caractérisé en ce que
   la gaine de la partie d'extrémité (10) de ladite fibre optique et la surface externe du corps constituant le dispositif de terminaison sont revêtues d'un revêtement polymère (26).

2. Article selon la revendication 1, dans lequel le revêtement polymère présente un indice de réfraction supérieur à celui du dispositif de terminaison.

3. Article selon la revendication 1, dans lequel le dispositif de terminaison a essentiellement le même diamètre que ladite fibre optique.

4. Article selon la revendication 1, dans lequel le dispositif de terminaison est attaché à ladite extrémité de la fibre optique au moyen d'une résine époxy d'indice adapté.

5. Article selon la revendication 4, dans lequel ladite résine époxy d'indice adapté a un indice de réfraction compris dans l'intervalle de 0,965 N à 1,035 N.

6. Article selon la revendication 1, dans lequel le dispositif de terminaison a une longueur supérieure ou égale à 3 cm.

7. Article selon la revendication 1, dans lequel le dispositif de terminaison est une fibre de silice sans coeur.

8. Article selon la revendication 7, dans lequel ladite fibre de silice sans coeur comprend du Ge.

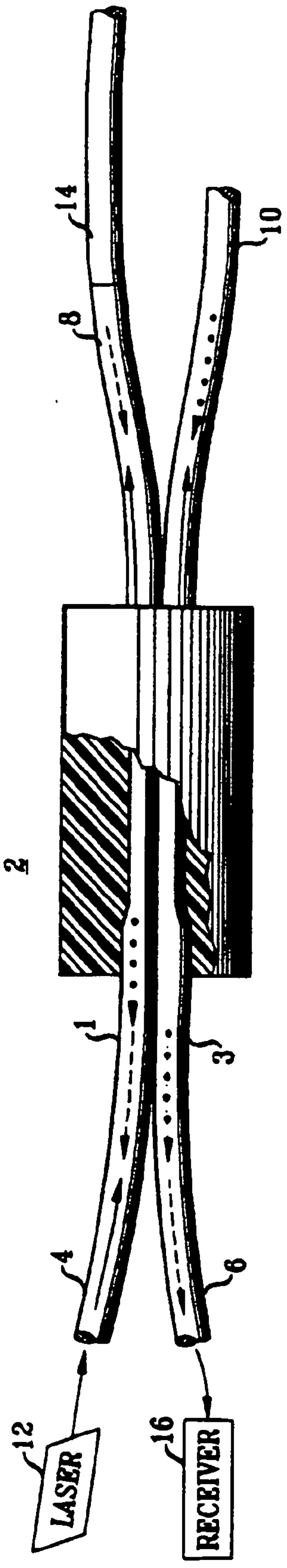

FIG. 1

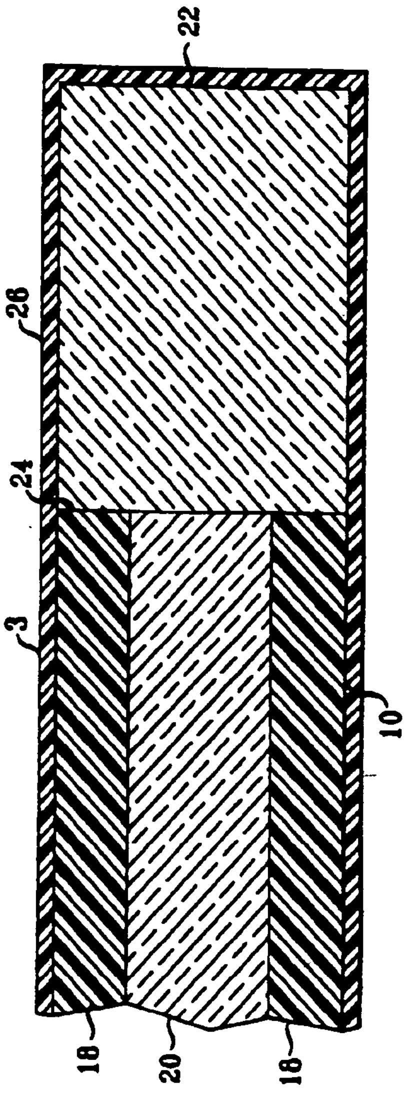

FIG. 2